PB80-159437

Evaluation of the Texaco Stratified Charge (TCCS) M-151 Army Vehicle

(U.S.) Environmental Protection Agency
Ann Arbor, MI

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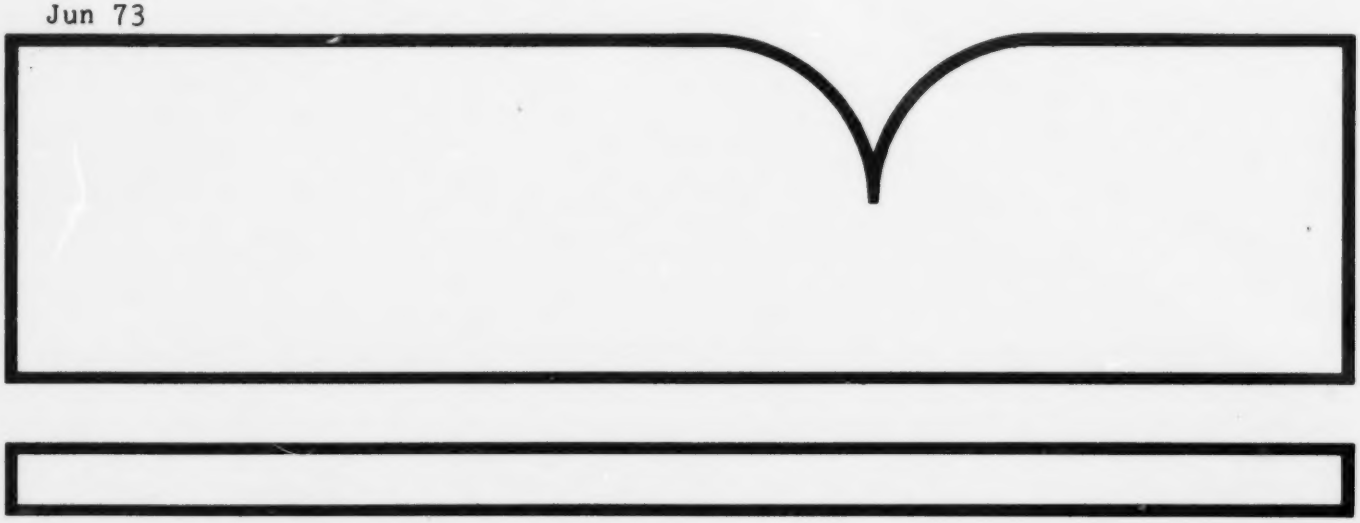

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Emission Control Technology Division
Office of Air & Water Programs
Environmental Protection Agency

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16. ABSTRACT

During the testing in May 1972, it was determined that the TCCS-powered M-151 vehicle met 1976 Federal emissions standards. Since the time a 50,000 mile durability test has been conducted on this vehicle by Texaco under contract with the U.S. Army. Although major engine and emission control system maintenance was required during the mileage accumulation, Texaco claimed 1976 emission levels were maintained. Included in the maintenance was: four individual replacements of various catalytic elements in the system; several ignition modifications; EGR system cleaning; and major valve train maintenance.

As part of EPA's cooperative effort with the U.S. Army and EPA's continuing interest in the emissions characteristics of this engine concept a confirmatory test program was scheduled in the EPA laboratory.

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Background

During testing in May of 1972 at MSAPC, it was determined that the TCCS-powered M-151 vehicle met 1976 Federal emissions standards. The following emission values are the average of three tests performed at the EPA laboratory at that time.

Hydrocarbon	0.37 gm/mi
Carbon Monoxide	0.23 gm/mi
Oxides of Nitrogen	0.30 gm/mi
Carbon Dioxide	551.6 gm/mi

Since that time a 50,000-mile durability test has been conducted on this vehicle by Texaco under contract with the U.S. Army. Although major engine and emission control system maintenance was required during the mileage accumulation, Texaco claimed 1976 emission levels were maintained. Included in the maintenance was: four individual replacements of various catalytic elements in the system; several ignition modifications; EGR system cleaning; and major valve train maintenance.

As part of EPA's cooperative effort with the U.S. Army and EPA's continuing interest in the emissions characteristics of this engine concept a confirmatory test program was scheduled in the EPA laboratory.

Vehicle Tested

The vehicle tested was an Army M-151 1/4-ton truck with a four-speed, manual transmission. The vehicle was powered with a 141 CID water-cooled, 4-cylinder, emissions-controlled version of Texaco's stratified charge, multi-fuel combustion process (TCCS).

The emission control system is schematically illustrated in the attached Figure 1. The system included:

a. A cooled EGR system used to control oxides of nitrogen. The system provided for two EGR rates. A high rate used for part load operation and a low rate for high load operation. The EGR system also incorporated a particulate trap and an EGR mixing device.

b. A platinum loaded close-coupled catalytic reactor whose design incorporated a tangental swirling action of the exhaust to provide for turbulence and mixing. In addition two reactors of a through flow design were employed, one loaded with platinum, one with copper chromite All catalytic reactors were Texaco designed and fabricated.

c. Intake air throttling at idle and light load was used to increase exhaust temperature during these modes of operation

Test Program

A series of tests were conducted in accordance with the 1975 model year certification procedure. Details of this procedure are described in the November 15, 1972, Federal Register. Steady state testing was also conducted.

During the majority of the EPA testing, the vehicle was operated on a mixture of Texaco no-lead pump fuel and a trace percentage lubricating oil. Due to the oil in the fuel, continuous analysis for hydrocarbon emissions was made using a heated flame ionization detector. Limited gas chromatographic analysis of exhaust samples was also conducted for methane content.

Test Results

The attached Table I presents the 1975 FTP emissions data compiled during the EPA evaluation of this vehicle. It is apparent that this vehicle met 1976 emissions levels. Also presented in this table is fuel economy for the driving schedule based on carbon balance calculations. The maximum speed data presented in this table, and the typical high speed sections of the driving schedule as given in Figures 2 and 3 illustrate that this vehicle could not meet all the acceleration requirements of the driving schedule and was not able to achieve the maximum 57 mph speed of the driving schedule.

Steady state emissions and carbon balance fuel consumption is given in the attached Table II. Fuel consumption data from this table indicates the highest steady state fuel consumption was at idle (1.73 gal/hr). This condition suggests that the engine was tuned for inefficiency at this point to provide for rapid cold start warm-up and elevated idle exhaust temperatures.

Exhaust samples from test number 356 were analyzed for methane using GC analysis. The bag 1, 2 and 3 hydrocarbon levels were respectively 4.25, .42, and .53 grams and were respectively analyzed to be composed of 19.6, 86.7, and 38.6% methane.

Conclusions

1. Although major engine and emission control system maintenance was required, after 50,000 miles of durability testing a TCCS-powered M-151 vehicle met the statutory 1976 mass emission standards.

2. The vehicle demonstrated poor driveability and low power throughout this testing.

3. Extensive use of catalytic reactors was required in Texaco's emission control system.

4. Trace quantities of lube oil in the fuel seemed to cause no measureable additional heavy hydrocarbon component in the exhaust as sampled during this testing.

Table I

1975 FTP Composite Results

							Avg.*	'76 STD
Test Number		325	326	335	346	356	366	~	~
Unburned Hydrocarbon (gm/mi)		0.96	0.53	0.34	0.28	0.34	0.22	0.30	0.41
Carbon Monoxide (gm/mi)		7.66	2.53	0.61	0.52	1.04	0.51	0.67	3.4
Oxides of Nitrogen (gm/mi)		0.27	0.27	0.33	0.36	0.31	0.34	0.34	0.4
Carbon Dioxide (gm/mi)		616.54	573.66	594.21	608.67	559.06	540.05	582.03	~
Fuel Economy** (mpg)		14.37	15.63	15.20	14.96	16.09	17.07	15.55	~
Max. speed during 505-second high speed cruise (mph) Regulation calls for 57 mph	Bag 1	48	51	~	48	49	45	48	~
	Bag 3	52	54	~	53	53	51	53	~

* Emission Avg. Neglects Tests 325 and 326

** Fuel economy based on carbon balance assumes: Fuel 86.6% wt. carbon
Fuel density: 6.167 lbs/gal

All tests conducted at 2750 lbs. inertia; 9.9 rear wheel hp at 50 mph.

Table II

Steady State Test Results

Gaseous Composition

Idle gm/5 min.	15 mph gm/mi	30 mph gm/mi	45 mph gm/mi	
0.06	0.14	0.00	0.02	HC
0.12	0.00	0.02	0.01	CO
0.42	0.06	0.17	0.25	NOx
1266.83	151.42	310.04	174.49	CO_2

Fuel Consumption*

N	3	4	4	Gear
~	46.4	28.3	30.2	mi/gal
1.73	0.32	1.06	1.49	gal/hr
253.4	47.3	155.0	218.1	gm CO_2/min

*1. Loading characteristic is per belt-driven Clayton Dynamometer set at 9.9 rear wheel hp at 50 mph.

2. Fuel consumption based on carbon balance.
Assumes: Fuel 86.6% wt. carbon
Fuel density: 6.167 lbs/gal

TCCS Emission Control System

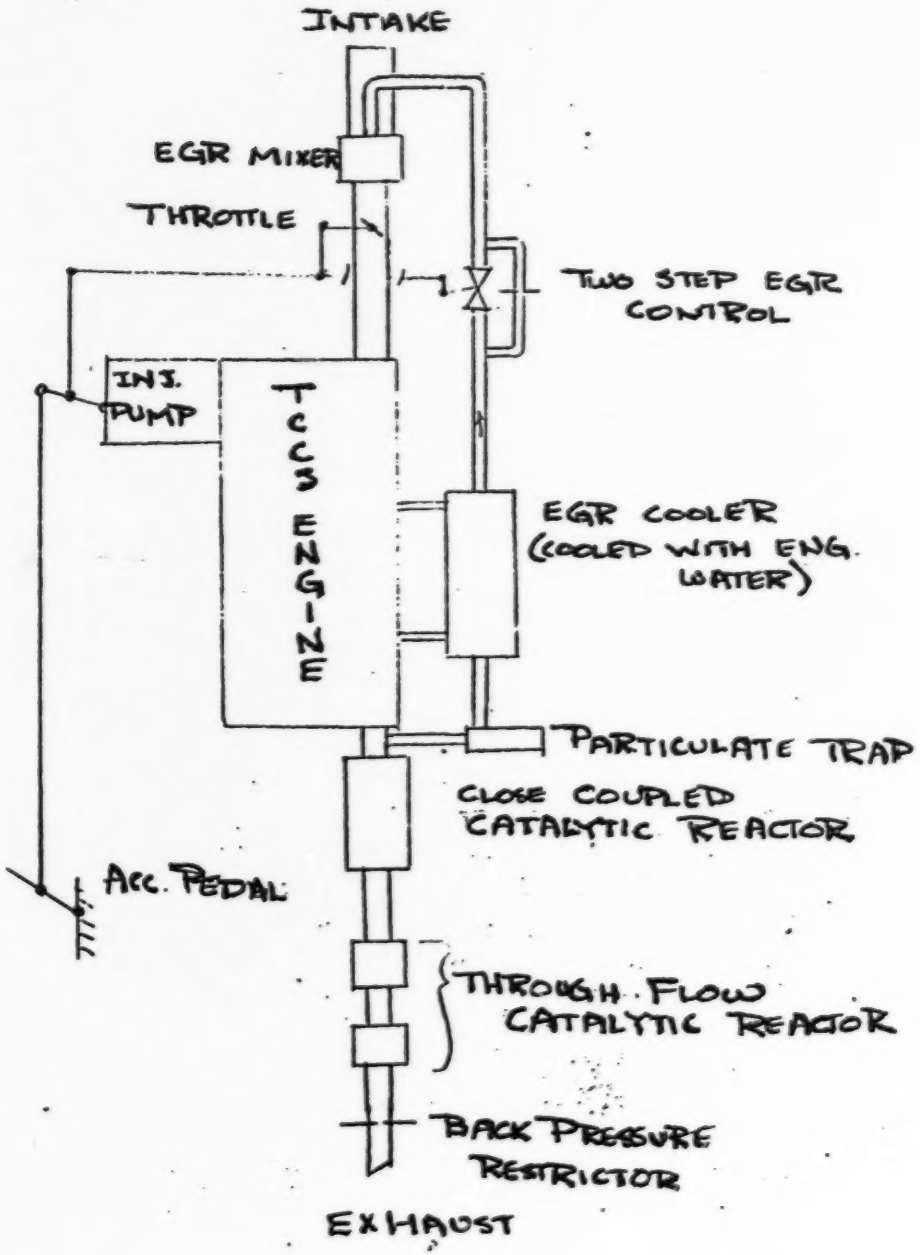

FIGURE 1

BAG 1 SPEED TRACE

HIGH SPEED SECTION

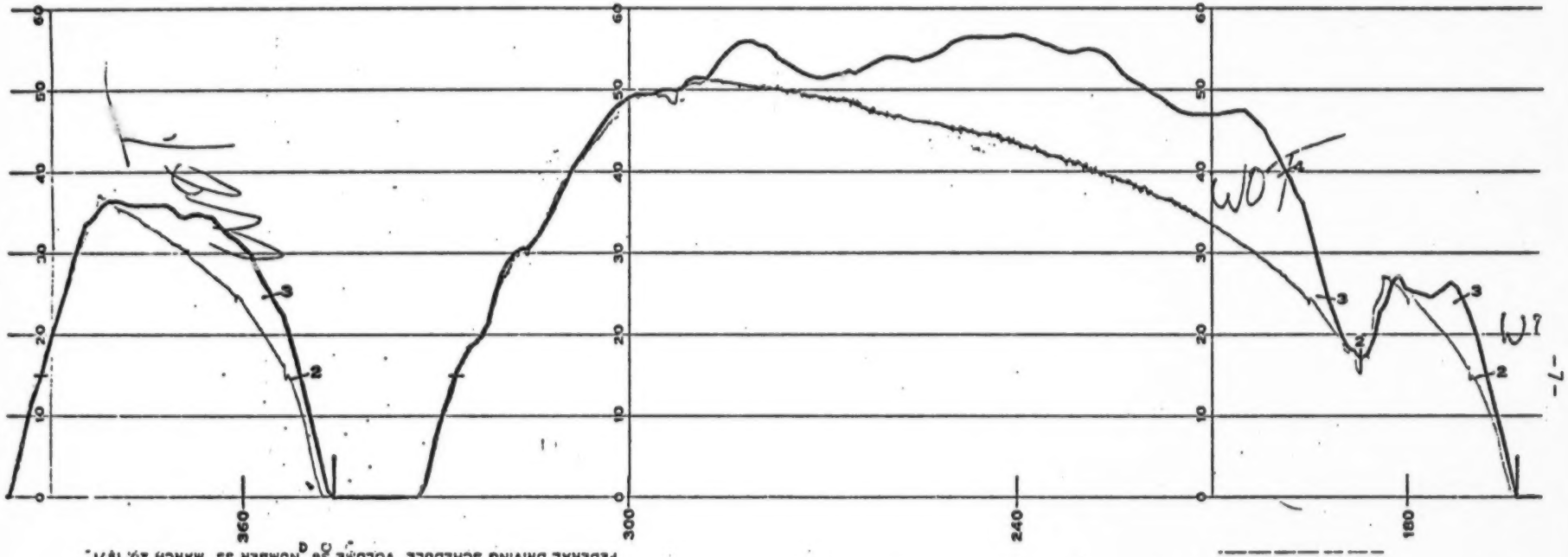

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FIGURE 2.

BAG 3 SPEED TRACE
HIGH SPEED SECTION

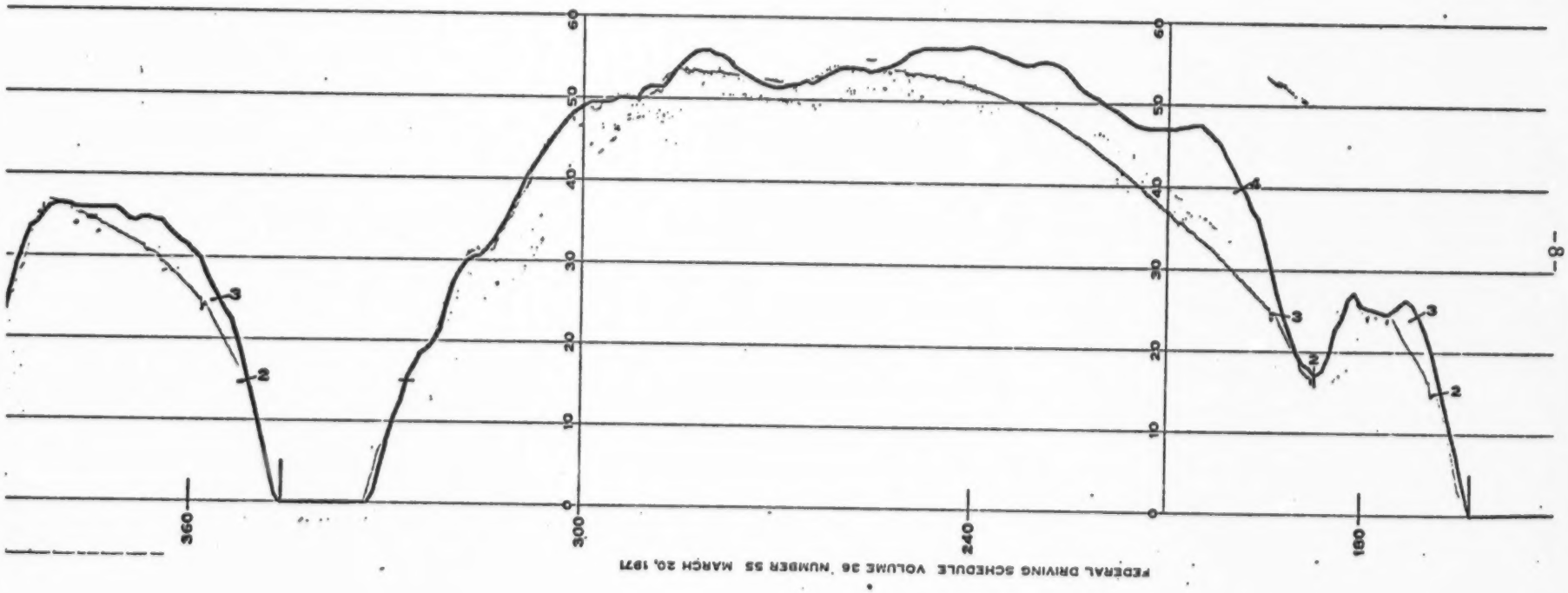

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FIGURE 3